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***January 1996***



***Biology 30***  
***Grade 12 Diploma Examination***

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January 1996

# Biology 30

## Grade 12 Diploma Examination

### Description

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 48 multiple-choice and 8 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, of equal value, worth 30% of the examination
- 80 total possible marks worth 100% of the examination

This examination contains sets of related questions.

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

When required, a grey bar is used to indicate the end of a set.

Tear-out data pages are included near the back of this booklet.

The blank perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

### Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

## Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

### Example

This examination is for the subject of

- A. biology
- B. physics
- C. chemistry
- D. science

Answer Sheet

● (B) (C) (D)

## Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

### Examples

#### Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is \_\_\_\_\_.

(Round and record your answer to three significant digits in the numerical-response section of the answer sheet.)

$$\begin{aligned}\text{Average} &= (21.0 + 25.5 + 24.5)/3 \\ &= 23.666 \\ &= 23.7\end{aligned}$$

Record 23.7 on the answer sheet →

2	3	.	7
●	●	●	●
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	●
8	8	8	8
9	9	9	9

### Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order is \_\_\_\_\_.  
(Record all four digits in the numerical-response section of the answer sheet.)

- 1 physics
- 2 chemistry
- 3 biology
- 4 science

Answer 3214

Record 3214 on the answer sheet →

3	2	1	4
0	0	0	0
1	1	2	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

### Selection Question and Solution

The birds in the following list are numbered \_\_\_\_\_.  
(Record your answer in ascending numerical order in the numerical-response section of the answer sheet.)

- 1 dog
- 2 sparrow
- 3 cat
- 4 robin
- 5 chicken

Answer 245

Record 245 on the answer sheet →


2	4	5	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

### Written Response

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.
- Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

*Do not turn the page to start the examination until told to do so by the presiding examiner.*





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Scientists study the endocrine and nervous systems to find treatments for disorders and to extend their knowledge of these systems.

1. Which gland produces a hormone that directly increases blood supply to skeletal muscles and increases the rate of contraction of heart muscle?
  - A. Pancreas
  - B. Adrenal gland
  - C. Thyroid gland
  - D. Pituitary gland
  
2. Which sequence illustrates a mechanism used by the body to control the blood glucose level?
  - A. Blood glucose increases → release of glucagon increases → conversion of glycogen into glucose decreases → blood glucose decreases
  - B. Blood glucose decreases → release of glucagon decreases → conversion of glycogen into glucose decreases → blood glucose increases
  - C. Blood glucose increases → release of insulin increases → conversion of glucose into glycogen increases → blood glucose decreases
  - D. Blood glucose decreases → release of insulin decreases → conversion of glucose into glycogen increases → blood glucose increases

*Use the following information to answer the next question.*

*Diabetes insipidus* is a disorder of the posterior lobe of the pituitary gland or hypothalamus resulting in decreased secretion of a specific hormone. This disorder is characterized by the excretion of large volumes of urine and subsequent dehydration and thirst.

A person with *diabetes insipidus* can be treated by inhaling a spray containing the hormone that is deficient. The spray is inhaled several times a day.

3. The inhaled spray would likely contain
  - A. insulin
  - B. glucagon
  - C. aldosterone
  - D. antidiuretic hormone

*Use the following information to answer the next two questions.*

When the Chernobyl nuclear reactor in Ukraine melted down, clouds of radioactive material, including iodine, were released into the atmosphere. Iodine is actively absorbed by a certain gland in the body. Scientists were worried that the radioactive iodine would cause tumours in this gland. In an attempt to avoid this problem, people who lived near the reactor were given large doses of non-radioactive iodine.

4. How would the ingestion of large doses of non-radioactive iodine reduce a person's chances of getting a tumour in a particular gland?
  - A. The pituitary would become saturated with non-radioactive iodine and this would limit the absorption of radioactive iodine.
  - B. The thyroid would become saturated with non-radioactive iodine and this would limit the absorption of radioactive iodine.
  - C. Increased levels of iodine would stimulate hormonal production by the pituitary and limit tumour formation.
  - D. Increased levels of iodine would stimulate hormonal production by the thyroid and limit tumour formation.
  
5. If a tumour caused increased secretion of thyroxine, which symptoms would likely be experienced by an affected person?
  - A. Increased body temperature and increased metabolic rate
  - B. Increased body temperature and decreased metabolic rate
  - C. Decreased body temperature and increased metabolic rate
  - D. Decreased body temperature and decreased metabolic rate
  
  
6. The pituitary hormone ACTH regulates the production of aldosterone by the cortex of the adrenal glands. A severe drop in ACTH levels would likely result in
  - A. decreased sodium ion retention and increased water loss because aldosterone levels would rise
  - B. decreased sodium ion retention and increased water loss because aldosterone levels would drop
  - C. increased sodium ion retention and increased water retention because aldosterone levels would rise
  - D. increased sodium ion retention and increased water retention because aldosterone levels would drop



7. Sensory and motor neurons of the peripheral nervous system transmit impulses between muscles and the
- A. parasympathetic nervous system
  - B. sympathetic nervous system
  - C. central nervous system
  - D. endocrine system
8. Which sequence correctly shows the path of sound transmission in the ear?
- A. Tympanic membrane → eustachian tube → semicircular canals → cochlea
  - B. Tympanic membrane → semicircular canals → eustachian tube → cochlea
  - C. Auditory canal → ossicles → tympanic membrane → organ of Corti
  - D. Auditory canal → tympanic membrane → ossicles → organ of Corti
9. A person with a vitamin A deficiency may have night blindness. The glare from the headlights of an approaching car will temporarily reduce that person's visual capacity. The primary structures associated with this change are the
- A. cornea and lens
  - B. retina and rod cells
  - C. fovea and blind spot
  - D. choroid and cone cells
10. A person who occasionally experienced paralysis was examined and found to have very low levels of potassium in the blood and other tissues. The paralysis likely resulted because of the inability of
- A. capillaries to provide adequate blood flow
  - B. axon terminals to break down acetylcholine
  - C. neurons to repolarize during the refractory period
  - D. neurons to remove acetylcholine from the synapse

Use the following information to answer the next three questions.

More than 4 000 Gulf War veterans complain of illness (Gulf War Syndrome). The veterans' symptoms include joint pain, shortness of breath, attention and memory problems, and chronic fatigue. During the war, most of the veterans took anti-nerve-gas pills. These pills contain pyridostigmine bromide, a drug that inhibits cholinesterase.

Pyridostigmine bromide is also used to treat patients with *myasthenia gravis*, an inherited disorder characterized by weakness of skeletal muscles.

11. The role of cholinesterase in neural transmission is to
  - A. increase the rate of nerve impulse transmission
  - B. promote the breakdown of a neurotransmitter
  - C. increase the sensitivity of neural membranes
  - D. promote the synthesis of a neurotransmitter
  
12. Considering that the symptoms of Gulf War Syndrome include attention and memory problems, it is likely that pyridostigmine bromide has an effect on the
  - A. cerebrum
  - B. cerebellum
  - C. hypothalamus
  - D. medulla oblongata
  
13. In *myasthenia gravis*, a malfunction of neuromuscular synapses occurs. The information presented above indicates that the muscular weakness associated with this disorder occurs because
  - A. axons secrete excess acetylcholine
  - B. axons secrete insufficient acetylcholine
  - C. of increased permeability of membranes to sodium ions
  - D. of decreased permeability of membranes to potassium ions



*Use the following information to answer the next question.*

Scientists had long assumed that the brain could not produce new cells. However, two researchers at the University of Calgary have successfully produced new brain tissue by using an unspecialized brain cell known as a stem cell. This stem cell acts as a “mother” cell to produce healthy brain tissue, in vitro.

14. Before this research, the assumption that brain cells could **not** regenerate was based upon which characteristic of axons?
- A. Axons of the peripheral nervous system are surrounded by a neurilemma.
  - B. Axons of the central nervous system are surrounded by a neurilemma.
  - C. Axons of the peripheral nervous system lack a neurilemma.
  - D. Axons of the central nervous system lack a neurilemma.

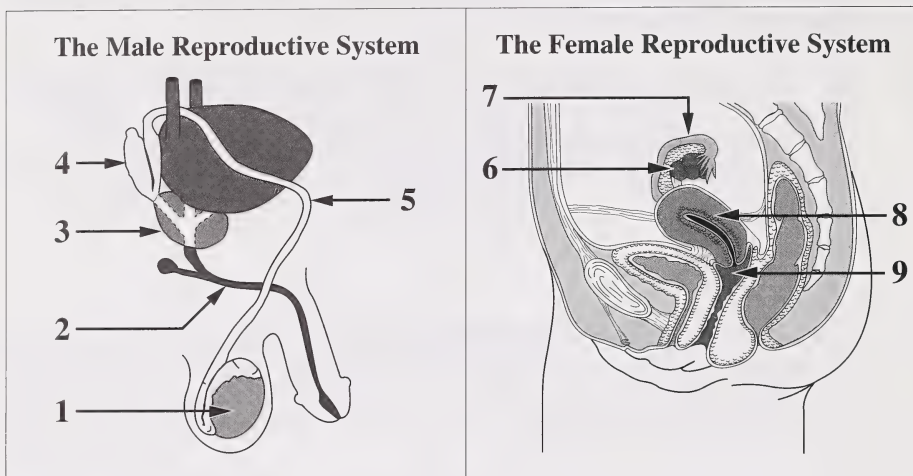
*Use the following information to answer the next question.*

Parkinson’s disease destroys certain neurons in the brain. One treatment for Parkinson’s disease is to transplant fetal brain tissue into a patient to replace neurons destroyed by the disease.

15. Which is a likely reason why fetal brain tissue, rather than brain tissue from an adult donor, is used to treat Parkinson’s disease?
- A. Fetal neurons can undergo meiosis but adult neurons cannot.
  - B. Fetal neurons can undergo mitosis but adult neurons cannot.
  - C. Adult neurons are more complex than fetal neurons.
  - D. Adult neurons are much larger than fetal neurons.

Reproductive processes may be affected by disease, the environment, or the use of technology.

Use the following information to answer the next two questions.



### Numerical Response

1. Provide the number of the reproductive structure that is **directly** affected by each technology named below.

(Record your **four-digit answer** in the numerical-response section of the answer sheet.)

Reproductive  
structure:

Technology:	Vasectomy	Tubal ligation	Castration	Use of an intrauterine device (IUD)
-------------	-----------	----------------	------------	---

16. The birth control pill prevents the maturation and release of ova. The structure that is directly affected by the birth control pill is
  - A. structure 6, because ova are produced by follicles in this organ
  - B. structure 6, because this organ will secrete excess estrogen and progesterone
  - C. structure 8, because implantation will not occur in this organ unless ovulation occurs
  - D. structure 8, because follicular development is controlled by feedback from this organ



17. The vas deferens is most similar in function to which female reproductive organ?
- A. Ovary
  - B. Uterus
  - C. Vagina
  - D. Fallopian tube

*Use the following information to answer the next question.*

**Possible Effects of Testosterone**

- 1 Inhibits skeletal muscle development
- 2 Enhances skeletal muscle development
- 3 Inhibits development of body hair
- 4 Promotes development of body hair
- 5 Inhibits gametogenesis
- 6 Stimulates gametogenesis
- 7 Enhances growth of the larynx
- 8 Inhibits growth of the larynx

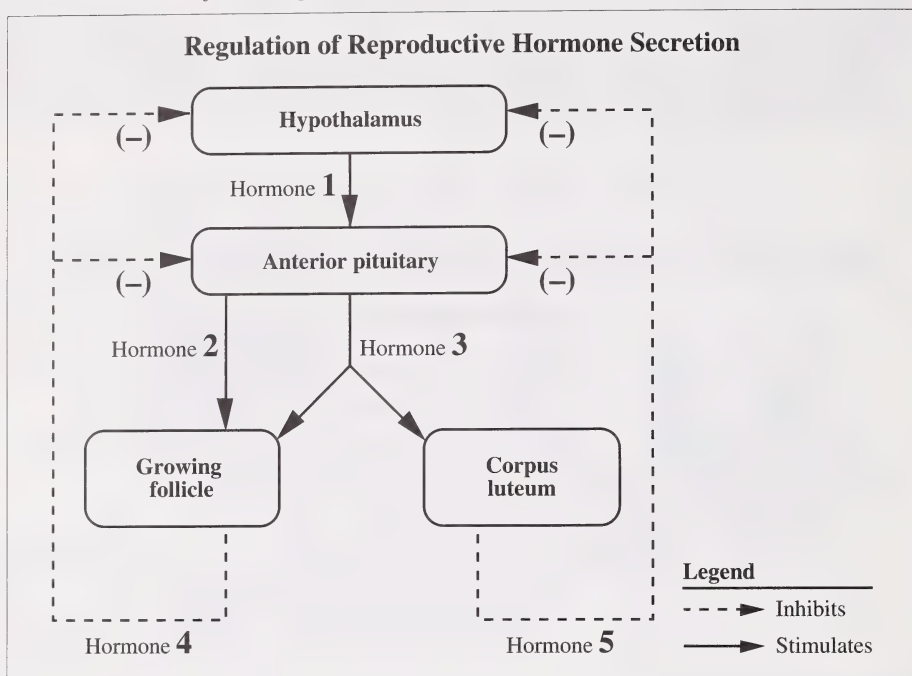
**Numerical Response**

2. Select all the correct effects of normal levels of testosterone in an adolescent male.

(Record your **answer in lowest-to-highest numerical order** in the numerical-response section of the answer sheet.)

Answer: \_\_\_\_\_

Use the following information to answer the next two questions.



18. Which row correctly identifies hormones 2, 3, 4, and 5?

Row	Hormone 2	Hormone 3	Hormone 4	Hormone 5
A	FSH	LH	Estrogen	Progesterone
B	LH	FSH	Estrogen	Progesterone
C	FSH	LH	Progesterone	Estrogen
D	LH	FSH	Progesterone	Estrogen

19. According to the diagram, secretion of hormone 1 is likely inhibited by

- A. increased levels of gonadotropins in the blood
- B. decreased levels of gonadotropins in the blood
- C. increased levels of ovarian hormones in the blood
- D. decreased levels of ovarian hormones in the blood



*Use the following information to answer the next two questions.*

Based on the principles of genetics and the analysis of cells produced by meiosis, it is predicted that male and female humans should be produced in equal numbers. However, the ratio of the number of males to females, known as the sex ratio, changes throughout the life cycle. The sex ratio at conception (comparing the number of "male" zygotes to "female" zygotes) is often as high as 1.6 to 1 in favour of males. The sex ratio at birth is 1.05 to 1 in favour of males. In adults aged 20 to 25 years, the sex ratio is 1 to 1. After age 25, the sex ratio shifts in favour of females.

20. Which row correctly identifies one genetic factor and one environmental factor that might cause the described changes in the sex ratio?

Row	Genetic Factor	Environmental Factor
A	X-linked disorders affect more males than females.	A male pre-embryo has a greater chance of successful implantation than a female pre-embryo.
B	X-linked disorders affect more females than males.	A male pre-embryo has a greater chance of successful implantation than a female pre-embryo.
C	X-linked disorders affect more males than females.	Accidents are the leading cause of death among males aged 15 to 35 years.
D	X-linked disorders affect more females than males.	Accidents are the leading cause of death among males aged 15 to 35 years.

21. Which statement provides the best explanation for the underlying cause of the sex ratio at conception?
- A. Sperm that contain an X chromosome are more motile than those that contain a Y chromosome.
  - B. Sperm that contain a Y chromosome are more motile than those that contain an X chromosome.
  - C. There is a greater probability that males will produce sperm that contain an X chromosome than those that contain a Y chromosome.
  - D. There is a greater probability that males will produce sperm that contain a Y chromosome than those that contain an X chromosome.

22. RU-486 is a drug that inhibits the action of progesterone. Hormones called prostaglandins cause the cervix to soften and dilate. Administering RU-486 and prostaglandins to a woman during pregnancy would likely cause
- A. expulsion of the fetus
  - B. accelerated fetal development
  - C. a decrease in secretion of HCG by the pituitary
  - D. an increase in the development of the endometrium
23. A home pregnancy test that is positive reveals the presence of a hormone in urine. This hormone is only present in the first trimester of pregnancy. Which hormone is detected by this home pregnancy test?
- A. Progesterone
  - B. Oxytocin
  - C. Relaxin
  - D. HCG
24. During pregnancy, menstruation is prevented by the action of
- A. estrogen, initially secreted by the ovaries and later by the pituitary gland
  - B. estrogen, initially secreted by the corpus luteum and later by the placenta
  - C. progesterone, initially secreted by the ovaries and later by the pituitary gland
  - D. progesterone, initially secreted by the corpus luteum and later by the placenta
25. A poorly developed uterine lining mainly affects the
- A. lifespan of the unfertilized egg
  - B. implantation of the fertilized egg
  - C. ability of the sperm to fertilize the egg
  - D. development of the egg within the ovary



Use the following information to answer the next question.

**Some Events that Occur During Birth**

- 1 The baby is expelled from the uterus.
- 2 Secretion of progesterone decreases and the release of oxytocin increases.
- 3 Dilation of the cervix increases and amniotic fluid is released.
- 4 The placenta separates from the endometrium and is expelled.

**Numerical Response**

- 3.** Provide the correct sequence of these four events that occur during birth.

(Record your **four-digit answer** in the numerical-response section of the answer sheet.)

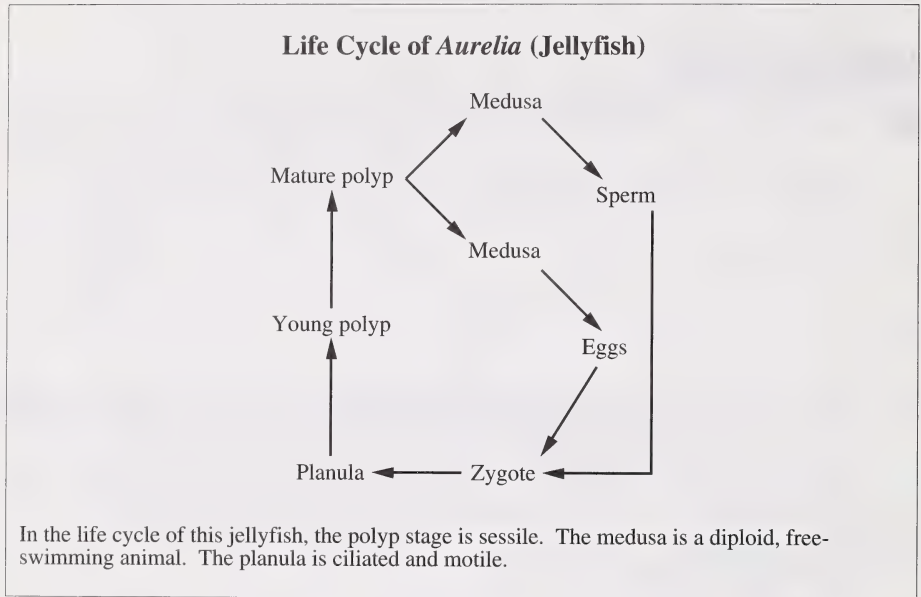
Answer: \_\_\_\_\_

- 26.** Infection by *Chlamydia* bacteria may cause tissue scarring that results in blockage of the Fallopian tubes. Without treatment, which event will still occur in an individual with this condition?

- A. Ovulation
- B. Parturition
- C. Fertilization
- D. Implantation

Studies of the life cycles of plants and animals reveal various adaptations and survival strategies.

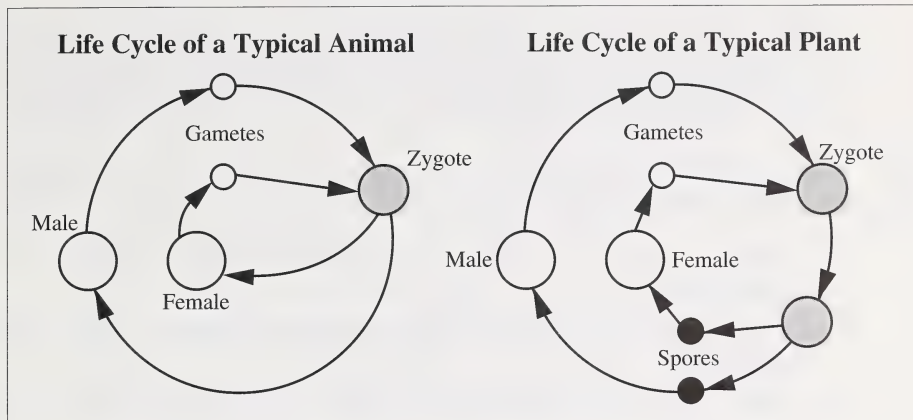
*Use the following information to answer the next question.*



27. Meiosis occurs in this life cycle when
- A. an egg and a sperm fuse to form a zygote
  - B. a mature polyp produces a medusa
  - C. a planula produces a young polyp
  - D. a medusa produces gametes



Use the following information to answer the next question.



28. Which structures normally have a haploid number of chromosomes?

- A. Seed plant spores and animal zygotes
- B. Seed plant spores and animal gametes
- C. Seed plant zygotes and animal zygotes
- D. Seed plant gametes and animal zygotes

Use the following information to answer the next question.

#### Some Events that Occur During Meiosis

- 1 Gametes are produced.
- 2 Spindles form and homologous pairs of chromosomes separate.
- 3 Centromeres divide and chromatid pairs separate.
- 4 Chromosomes are replicated.

#### Numerical Response

4. Provide the correct sequence of these four events that occur during meiosis.

(Record your **four-digit answer** in the numerical-response section of the answer sheet.)

Answer: \_\_\_\_\_

*Use the following information to answer the next question.*

Mature red blood cells lack a nucleus. Approximately 2 million red blood cells are destroyed every second in the circulatory system. All blood cells differentiate from a common source—a population of pluripotent stem cells in the bone marrow. Pluripotent refers to the potential of these cells to form any type of blood cell.

29. Which statement best explains why the number of red blood cells in the human body can be maintained?
- A. Mature red blood cells retain sufficient mRNA for replication and transcription.
  - B. Pluripotent stem cells undergo cell division continuously to produce new red blood cells.
  - C. Other types of mature blood cells undergo differentiation to form new red blood cells.
  - D. Mature red blood cells, before they are destroyed, undergo cytoplasmic cleavage repeatedly to produce more red blood cells.



Use the following information to answer the next three questions.

A sheep farm in central Alberta is located on a plot of land 3.00 km by 2.00 km. There are 858 female sheep and 42 male sheep on the farm. The farmer has constructed shelters for the sheep and provides them with food and water to supplement the graze that is naturally available.

30. Which statement describes the likely effect of the intervention by the farmer on the sheep population growth rate ( $r$ )?
- A.  $r$  would be negative because  $b$  would increase and  $d$  would decrease.
  - B.  $r$  would be negative because  $b$  would decrease and  $d$  would increase.
  - C.  $r$  would be positive because  $b$  would increase and  $d$  would decrease.
  - D.  $r$  would be positive because  $b$  would decrease and  $d$  would increase.

### Numerical Response

5. Calculate the population density (sheep/km<sup>2</sup>) of the sheep on this farm.

(Record your **answer rounded to three significant digits** in the numerical-response section of the answer sheet.)

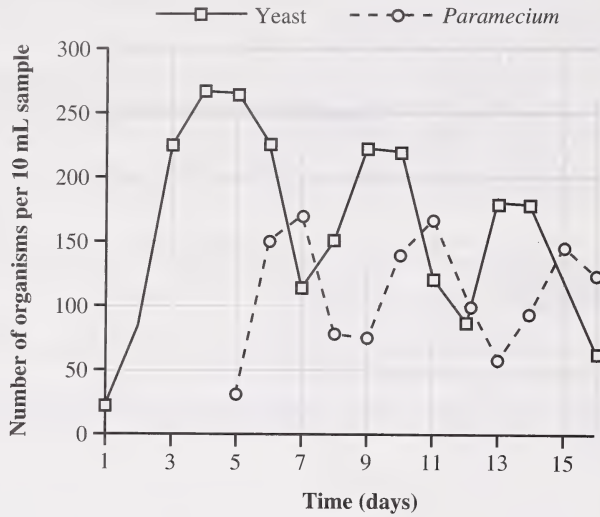
Answer: \_\_\_\_\_

31. The sheep liver fluke is an organism that lives in the intestines, liver, brain, and lungs of sheep and causes tissue damage in these organs. Which statement best describes the likely effect of a severe infestation of sheep liver flukes on a sheep population?
- A. Commensalism would reduce the carrying capacity of the sheep population.
  - B. Parasitism would reduce the carrying capacity of the sheep population.
  - C. Commensalism would reduce the density of the sheep population.
  - D. Parasitism would reduce the density of the sheep population.

Use the following information to answer the next two questions.

### Populations of Yeast and *Paramecium*

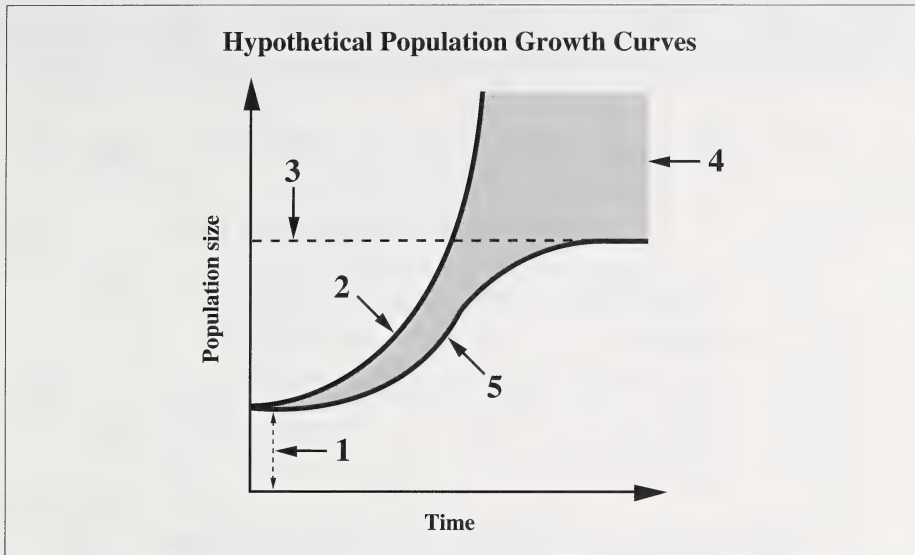
A suspension of yeast cells was added to a sucrose solution (nutrient medium) and incubated at 25°C for 16 days. On the fifth day, a small culture of the ciliate *Paramecium* was added. Each day, a 10 mL sample was withdrawn, the number of organisms present was determined, and the sample was returned to the mixture. The data collected were recorded on the following graph.



32. The two factors that were likely responsible for the fluctuations in the population of yeast from day 4 to day 16 were
- A. predation and limited food supply
  - B. temperature intolerance and predation
  - C. limited food supply and overcrowding
  - D. overcrowding and temperature intolerance
33. A likely cause of the change in the yeast population from day 7 to day 9 was
- A. an increase in nutrient concentration
  - B. an increase in environmental resistance
  - C. a decrease in the *Paramecium* population
  - D. a decrease in population density of the yeast



Use the following information to answer the next question.



### Numerical Response

6. Select the set of four numbers from the graph that correctly completes the following statement.

Plotting uncontrolled, rapid population growth results in the curve labelled \_\_\_\_\_. However, the effect of environmental resistance, labelled \_\_\_\_\_, normally limits growth, resulting in the curve labelled \_\_\_\_\_. The population size becomes stable when the carrying capacity, labelled \_\_\_\_\_, is reached.

(Record your **four-digit answer** in the numerical-response section of the answer sheet.)

Answer: \_\_\_\_\_

The structures and functions of organisms are determined in part by their genomes.

Use the following information to answer the next two questions.

**Some Inherited Traits in House Cats**

Dominant Trait	Allele	Recessive Trait	Allele
Pointed ears	<i>P</i>	Folded ears	<i>p</i>
Smooth hair	<i>S</i>	Curly hair	<i>s</i>
Polydactyly (more than 5 digits on paws)	<i>D</i>	Five digits on paws	<i>d</i>

Assume that all of the alleles shown above exhibit independent assortment.

34. A folded-eared female mated with a male of unknown phenotype. All six of their offspring had pointed ears. What were the most probable genotypes of the parents?
- A. *pp* and *PP*
  - B. *Pp* and *Pp*
  - C. *pp* and *Pp*
  - D. *pp* and *pp*

**Numerical Response**

7. A curly-haired, five-digited male was crossed with a female that was heterozygous for both hair type and the number of digits on the paws. What is the probability of this mating producing offspring that have curly hair **and** are heterozygous for the number of digits on the paws?

(Record your answer as a value from 0 to 1, rounded to two significant digits, in the numerical-response section of the answer sheet.)

Answer: \_\_\_\_\_

Use the following information to answer the next two questions.

In *Drosophila*, ebony body colour is caused by the recessive allele *eb* and grey body colour by the dominant allele *eb*<sup>+</sup>. Vestigial wings are produced by the recessive allele *vg* and long wings by the dominant allele *vg*<sup>+</sup>.

When mated, a female with ebony body colour and vestigial wings produced the following offspring:

- 41 flies with ebony body and long wings
- 44 flies with grey body and long wings
- 39 flies with grey body and vestigial wings
- 46 flies with ebony body and vestigial wings

35. What was the genotype of the male parent in this cross?
- A. *eb*<sup>+</sup>*eb*<sup>+</sup> *vg*<sup>+</sup>*vg*<sup>+</sup>
  - B. *eb*<sup>+</sup>*eb* *vg*<sup>+</sup>*vg*<sup>+</sup>
  - C. *eb*<sup>+</sup>*eb* *vg*<sup>+</sup>*vg*
  - D. *eb*<sup>+</sup>*eb* *vgvg*
36. How many of the 44 offspring with grey bodies and long wings would be expected to be heterozygous for body colour?
- A. 44
  - B. 33
  - C. 22
  - D. 11



Use the following information to answer the next two questions.

An anemic condition in humans called thalassemia results from decreased production of hemoglobin. Three genes control the condition: *N* (normal hemoglobin), *Thal-1* (thalassemia 1), and *Thal-2* (thalassemia 2). Possible genotypes and phenotypes for the trait are shown below.

Genotype	Phenotype
<i>NN</i>	No anemia
<i>N Thal-1</i>	Mild anemia
<i>N Thal-2</i>	Mild anemia
<i>Thal-2 Thal-2</i>	Mild anemia
<i>Thal-2 Thal-1</i>	Moderate anemia
<i>Thal-1 Thal-1</i>	Fatal—embryo or fetus dies before birth

37. Which statement is consistent with the information given?
- A. *Thal-1* and *Thal-2* are codominant and *N* is dominant.
  - B. *Thal-1* is dominant over both *N* and *Thal-2*.
  - C. *N* is dominant over both *Thal-1* and *Thal-2*.
  - D. *N*, *Thal-1*, and *Thal-2* are codominant.
38. If a male with the genotype *N Thal-1* and a female with the genotype *N Thal-2* have a child, the probability of that child having some degree of anemia (either mild or moderate) is
- A. 1.00
  - B. 0.75
  - C. 0.50
  - D. 0.25

Many scientific research projects are conducted at the molecular level.

*Use the following information to answer the next four questions.*

The human nose can distinguish up to 10 000 different odours. Airborne odour molecules are trapped by ciliated olfactory receptors. These receptors initiate impulses to the olfactory bulbs, which relay the signals to the temporal lobe of the cerebrum for interpretation.

Recently, researchers Linda Buck and Richard Axel of Columbia University have been able to identify some odour-receptor proteins on the nasal cells of rats. These receptor proteins, embedded in the cell membranes of ciliated neurons, are thought to bind with specific odour molecules, initiating a nerve impulse. The researchers have also found the genes responsible for the production of more than 100 types of odour-receptor proteins.

39. Olfactory receptors are categorized as
- A. mechanical receptors that are attached to the dendrites of neurons
  - B. mechanical receptors that are attached to the axons of neurons
  - C. chemoreceptors that form a synapse with the dendrites of neurons
  - D. chemoreceptors that form a synapse with the axons of neurons
40. Airborne molecules are thought to bind to odour-receptor proteins. These odour-receptor proteins initiate the smelling process by
- A. breaking down a neurotransmitter within the membrane of the neuron
  - B. making the membrane of the neuron more permeable to  $\text{Na}^+$  ions
  - C. changing the threshold of the membrane of the neuron
  - D. causing the neuron to be polarized
41. The ability to smell some odours and not others is an inherited trait. This trait is an example of
- A. incomplete dominance
  - B. crossing over
  - C. a phenotype
  - D. a genotype

*Continued*

42. If a gene responsible for the production of an odour-receptor protein underwent a mutation, one result might be
- A. a decrease in the ability to smell a specific odour
  - B. an increase in the ability to smell a variety of other odours
  - C. a decrease in protein synthesis within all olfactory neurons
  - D. an increase in threshold levels of stimulation for receptor neurons
- 

*Use the following information to answer the next two questions.*

Some researchers are investigating the hypothesis that feeding cow's milk to children less than nine months old could play a role in the development of type I (juvenile) diabetes mellitus in those genetically prone to the disease. A child who has inherited certain genes synthesizes antibodies in response to a particular fragment of a protein found in cow's milk. These antibodies attack the milk-protein fragment and some of the child's cells. After a child reaches the age of nine months, the immune system develops sufficiently to distinguish between the milk-protein fragment and the child's cells.

43. If a child who is genetically prone to juvenile diabetes has consumed cow's milk, it is likely that the child's blood contains antibodies that attack the
- A. sensory cells of the hypothalamus
  - B. glycogen storage cells of the liver
  - C. secretory cells of the thyroid
  - D. islet cells of the pancreas
44. A correct inference is that the antibodies produced in response to cow's milk are
- A. nucleic acids containing a sequence of amino acids
  - B. nucleic acids containing a sequence of nucleotides
  - C. proteins containing a sequence of amino acids
  - D. proteins containing a sequence of nucleotides



*Use the following information to answer the next three questions.*

The Romanovs, the Russian royal family, were shot dead during the Russian Revolution in 1918. The family included Czar Nicholas II and his wife Alexandra; their daughters, Olga, Maria, Tatiana, and Anastasia; and their son Alexis, who was a hemophiliac.

In 1992, scientists in Russia started work on the identification of skeletons thought to be the remains of the Czar, his wife, and three of their daughters. The researchers crushed and partially dissolved some bones to extract DNA.

To determine which skeletons belonged to the Romanovs, the researchers analyzed samples of mitochondrial DNA. Mitochondrial DNA is passed on only from mother to child. Some parts of mitochondrial DNA are very stable and mutate only once every 6 000 years. The researchers also obtained a sample of mitochondrial DNA from Prince Philip of England. His maternal grandmother was Alexandra's sister.

45. Which observation correctly accounts for the fact that mitochondrial DNA is passed on only from mother to child?
- A. Eggs contain mitochondria and sperm do not.
  - B. Mitochondrial DNA is transcribed from a template on the XY chromosome set.
  - C. Mitochondrial DNA is transcribed from a template on the XX chromosome set.
  - D. An egg contributes both its nucleus and its cytoplasm to a zygote, while a sperm contributes only its nucleus.
46. From which people would samples of mitochondrial DNA be nearly identical?
- A. Prince Philip, Czar Nicholas II, and Alexandra
  - B. Alexis, Prince Philip, and Czar Nicholas II
  - C. Czar Nicholas II, Alexandra, and Alexis
  - D. Alexandra, Alexis, and Prince Philip

### **Numerical Response**

8. Czar Nicholas II was **not** a hemophiliac. His wife, Alexandra, was a carrier for hemophilia. What was the probability that any of their daughters was a carrier for hemophilia?

(Record your **answer as a value from 0 to 1**, rounded to two significant digits, in the numerical-response section of the answer sheet.)

Answer: \_\_\_\_\_

Use the following information to answer the next two questions.

William Jia, a researcher at the University of British Columbia, thinks a genetically altered *Herpes* virus may one day be used to destroy gliomas, a type of brain cancer that attacks the frontal lobes of the cerebrum.

Jia managed to genetically engineer a *Herpes* virus that replicates only in rapidly dividing cancer cells and thus destroys only those cells. Jia handicaps the *Herpes* virus by deleting the genes that code for an enzyme needed for viral replication. This prevents the virus from replicating in normal, non-dividing brain cells, but enable it to continue replicating in cancerous brain cells. As the virus replicates, the rapidly dividing cancer cells are killed.

47. The deletion of genes from the *Herpes* virus likely involves the use of
- A. biopsies and chorionic villus sampling
  - B. karyotyping and pedigree analysis
  - C. amniocentesis and chromosome mapping
  - D. restriction enzymes and ligases
48. After the destruction of the cells in a brain tumour, the altered *Herpes* virus will likely
- A. change into a form capable of producing the enzymes necessary for the reproductive cycle of the virus
  - B. spread to other areas of the body and attack other types of cancer cells that may be present
  - C. enter a dormant stage because enzymes required for replication are absent
  - D. spread to a nearby region of the brain and begin normal replication

*The written-response questions follow on the next page.*



*Use the following information to answer the next question.*

The Saguenay River community, located about 200 km from Quebec City, has the world's highest incidence—1 in 500—of myotonic dystrophy. It is an inherited disease that affects the muscles and nerves of its victims. Typically, myotonic dystrophy affects 1 in 7 500 Canadians.

An international research team has isolated the gene that causes this disease. The myotonic dystrophy gene has an interesting characteristic: the gene size expands with each generation through the addition of extra nitrogen bases. The greater the degree of expansion, the greater the severity of symptoms. In addition, greater gene expansion increases the likelihood of offspring being born with myotonic dystrophy. Diagnosis of carriers can now be done with a simple blood test.

A twenty-four-year-old woman and a twenty-two-year-old man from the Saguenay River community were both unaffected by myotonic dystrophy. They sought genetic counselling before marriage. The counsellor collected data from their living relatives and recorded the information in a table.

Woman's Family			Man's Family		
Relative	Age	Myotonic Dystrophy	Relative	Age	Myotonic Dystrophy
maternal* grandmother	69	no	paternal** grandmother	77	no
maternal grandfather	71	yes	paternal grandfather	74	no
mother	48	no	paternal grandmother's brother	78	yes
father	49	no	mother	46	no
sister	21	no	father	51	yes
brother	23	yes	brother	20	no
			sister	19	yes

\* Maternal means "on the mother's side of the family."

\*\* Paternal means "on the father's side of the family."

**Written Response – 15% (12 marks)**

(1 mark)

1. a. Provide a hypothesis to explain why the incidence of this disease is higher in the Saguenay River community than in the rest of Canada.

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- b. Construct a pedigree to illustrate the data in the table and the information given about the man and the woman who are seeking genetic counselling. Use the symbols shown on the tear-out data pages when constructing your pedigree.

**(3 marks)**

- c. Based on the data, identify the mode (type) of inheritance for myotonic dystrophy. Describe one piece of evidence to support your choice.

**(2 marks)**

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*Continued*

(2 marks)

- d. If the man and woman who are seeking genetic counselling married and had a child, predict the probability that the child would have myotonic dystrophy. Show your method and/or calculations.

(1 mark)

- e. To what degree would your pedigree be useful for predicting the severity of myotonic dystrophy in offspring?

Not at all useful \_\_ Not useful \_\_ Useful \_\_ Somewhat useful \_\_ Very useful \_\_

Explain:

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*Continued*





*Use the following information to answer the next question.*

In the 1970s, researchers felt that humanity's victory over infectious disease was just a matter of time. Diseases such as polio, smallpox, diphtheria, tetanus, and tuberculosis were either eradicated or became non-threatening inconveniences that could be treated with the proper immunizations.

Today, some drug-resistant bacteria are reversing human victories over infectious disease. Bacteria can become resistant to antibiotics by natural selection. Non-resistant bacteria are killed by the antibiotic, but resistant bacteria survive and reproduce. Nearly every type of disease-causing bacterium known to medicine has become resistant to at least one antibiotic.

Human behaviour makes the situation worse. Doctors may over-prescribe antibiotics. Patients may stop taking antibiotics when their symptoms go away but before the infection is cleared up. In this way, non-resistant bacteria are killed, but partially resistant bacteria flourish. Some farmers use low levels of antibiotics in cattle feed. Animals grow faster because their energy is not wasted fighting infections. However, bacteria in cattle may become resistant to antibiotics and this immunity may also be transferred to bacteria in humans because the antibiotic is present in the meat or milk that humans consume.

The problem described above is related to the nature and function of DNA within bacterial cells; i.e. its ability to mutate and its function in directing the processes of the cell and cell division. The problem is also related to the *r*-selected nature of bacteria populations. In other words, the problem is predictable. Because nature is so complex, scientific study often looks at only one aspect at a time and it is difficult for scientists, or anyone, to see the whole picture. Often, the technologies used by our society cause problems because these technologies are based on a limited or partial understanding of how nature operates.

**Written Response – 15% (12 marks)**

2. **Explain** how the development of drug-resistant bacteria is related to DNA's capacity to mutate and DNA's role in directing the functions of the cell.

**Explain** how the development of drug-resistant bacteria is related to the *r*-selected nature of bacteria populations.

**Illustrate** how two technologies, other than the use of antibiotics, have caused environmental, health, or societal problems because they were based on a partial view of the way nature functions. (Provide the intended use of each technology and describe a problem created by its use.)







*You have now completed the examination.  
If you have time, you may wish to check your answers.*





**BIOLOGY DATA**

**Symbols**

Symbol	Description	Symbol	Description
<i>A</i>	area	>	greater than, dominant over
<i>B</i>	births during time interval	<	less than, recessive to
<i>b</i>	per capita births ( $B/N$ )	=	equal to, codominant with, incompletely dominant with
<i>D</i>	deaths during time interval	/	divided by, “out of”
<i>d</i>	per capita deaths ( $D/N$ )	×	multiplied by, times, crossed with, mated with
<i>D<sub>p</sub></i>	population density	Δ	change
<i>K</i>	carrying capacity	♂	male
<i>N</i>	population size	♀	female
Δ <i>N</i>	change in population size	<i>n</i>	chromosome number
<i>PG%</i>	population growth (percent)	<i>I<sup>A</sup>, I<sup>B</sup>, i</i>	alleles (human blood type) ABO system ( $I^A = I^B, I^A > i, I^B > i$ )
<i>r</i>	per capita population growth rate ( $b - d$ )	<i>t</i>	time
<i>V</i>	volume	Δ <i>t</i>	change in time

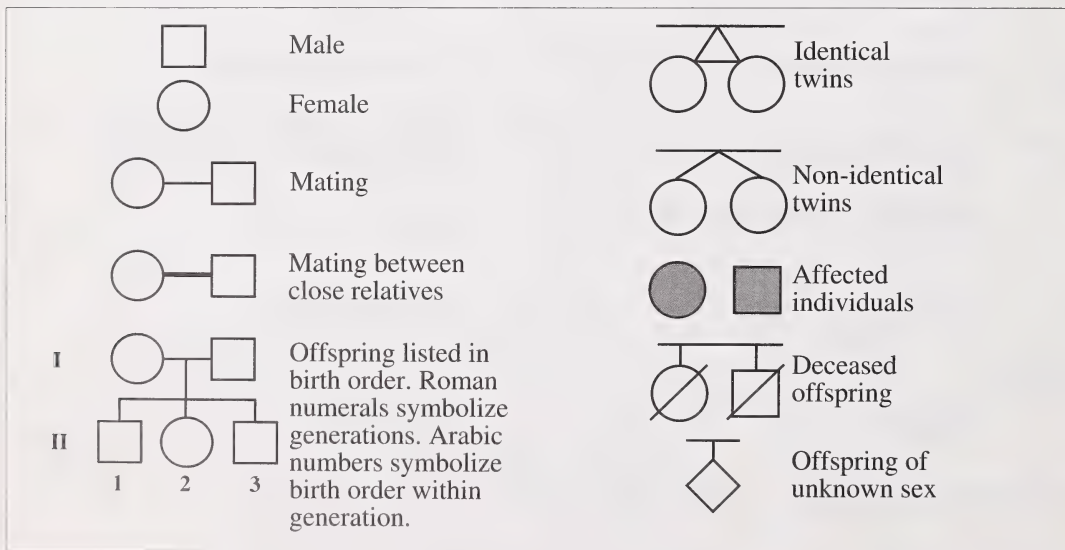
**Equations**

Subject	Equation
Hardy-Weinberg principle	$p^2 + 2pq + q^2 = 1$
Population density	$D_p = \frac{N}{V}$ or $D_p = \frac{N}{A}$
Change in population size	$\Delta N = (\text{factors that increase pop.}) - (\text{factors that decrease pop.})$
Population growth (%)	$PG\% = \frac{\Delta N \times 100\%}{N}$

## Abbreviations for Some Hormones

Hormone	Abbreviation
Adrenocorticotropin hormone	ACTH
Antidiuretic hormone	ADH
Follicle stimulating hormone	FSH
Human chorionic gonadotropin	HCG
Luteinizing hormone	LH (formerly ICSH in males)
Parathyroid hormone	PTH
Prolactin	PRL
Somatotropin (human growth hormone or growth hormone)	STH (HGH or GH)
Thyroid stimulating hormone	TSH

## Pedigree Symbols



**Messenger RNA Codons and Their Corresponding Amino Acids**

		S	E	C	O	N	D	B	A	S	E		
		U		C		A		G					
F	U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U	T		
		UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys	C			
I		UUA	Leu	UCA	Ser	UAA	STOP**	UGA	STOP**	A	H		
		UUG	Leu	UCG	Ser	UAG	STOP**	UGG	Trp	G			
R													
S	C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U	R		
		CUC	Leu	CCC	Pro	CAC	His	CGC	Arg	C			
		CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg	A			
		CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg	G			
T													
B	A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U	B		
		AUC	Ile	ACC	Thr	AAC	Asn	AGC	Ser	C			
		AUA	Ile	ACA	Thr	AAA	Lys	AGA	Arg	A			
		AUG	Met or START*	ACG	Thr	AAG	Lys	AGG	Arg	G			
A													
S	G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U	S		
		GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly	C			
		GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly	A			
		GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly	G			
E													

\* Note: AUG is an initiator codon but also codes for the amino acid methionine.

\*\* Note: UAA, UAG, and UGA are terminator codons.

**Abbreviations for Amino Acids**

Amino Acid	Abbreviation
Alanine	Ala
Arginine	Arg
Asparagine	Asn
Aspartate	Asp
Cysteine	Cys
Glutamate	Glu
Glutamine	Gln
Glycine	Gly
Histidine	His
Isoleucine	Ile
Leucine	Leu
Lysine	Lys
Methionine	Met
Phenylalanine	Phe
Proline	Pro
Serine	Ser
Threonine	Thr
Tryptophan	Trp
Tyrosine	Tyr
Valine	Val

**Information About Nitrogen Bases**

Nitrogen Base	Classification	Abbreviation
Adenine	Purine	A
Guanine	Purine	G
Cytosine	Pyrimidine	C
Thymine	Pyrimidine	T
Uracil	Pyrimidine	U





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